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Inductive Reasoning at the Grade School Level

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INDUCTIVE REASONING

AT THE

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VITA AUCTORIS

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CHAPTER 1

INTRODUCTION

Never before, in all history, has civilization been exposed to such an abundance of new products, from do-nothing gadgets and gimmicks, on the one hand, to highly technical and complicated computers on the other. Daily the TV, radio, newspapers and magazines keep persons ever aware of the steadily increasing number and complexity of these new and most "necessary" discoveries of mankind.

In addition to this bombardment of things is the even greater flood of ideas and theories which accompany them as well as those which form the foundations of the political, theological and scientific issues of this time. Often contradictory, these concepts sometimes seem to be in constant battle for their acceptance by individual persons.

How does the inventor put together his new product and make it work? How does the scientist discover new laws of nature, the historian extract the major factors of a particular war or the theologian develop his concept of man's salvation? Moreover, how do persons decide which product to buy, for whom to vote or which faith to embrace, to name just a few of the countless decisions faced daily?

Let us consider, for example, the inventor. He must first have some understanding of what he is trying to do, and how his materials might work together to produce his desired effect. He must rely on facts he already knows and if necessary seek to learn some things he does not yet know. On the basis of these facts he forms a calculated guess, or theory, and according to this theory and the principles he sees to be involved, he proceeds to construct his product. If, however, his facts are inaccurate and his theories and principles inappropriate, his finished product will be ineffective.

The inventor, therefore, and in like manner also the scientist, theologian, philosopher and historian, find themselves of necessity concerned with not only the acquisition of new knowledge but also the verification of the truths upon which this new knowledge is based. The proper acquisition of knowledge and the verification of those inherent truths behind all "new" concepts, whether basic to the construction and use of material objects or in themselves purely conceptual, become therefore most crucial. For many years, persons realizing this have concerned themselves with the study of knowledge itself and ways in which it is acquired. This acquisition and development of knowledge is more popularly known as reasoning.

Reasoning, or as it is also often called, thinking or inference, has been described as ". . . the process by which new facts are attained from concepts and relationships already apprehended. (It) represents the extension of knowledge without the mediation of perception."[1] Uncounted volumes have been written through the centuries in an attempt to analyze and clarify this apparently simple but basically complex process. It seems only appropriate therefore to turn briefly at this time to some discussion of reasoning itself.

To trace this process of reasoning to its logical foundations, one must go back all the way to some of the philosopher's fundamental laws or first principles -- in other words, those laws, the truths of which in their very stating, are so apparent, they are felt to be universally acceptable without the need for other verification. Those here applicable are the Principle of Causality and the Uniformity of Nature.

The first of these two, the Principle of Causality is itself derived from other of these fundamental laws, namely the Principle of Identity, the Principle of Contradiction and the Principle of Sufficient Reason. Stated very simply, a thing either is, or is not, but <u>if</u> it is, there must be sufficient reason for it to be. Each individual effect, therefore, must have an adequate cause. Stated conversely, every cause must have an effect, this then becomes the Principle of Causality.

But it is not enough to know that every cause must have an effect. If the foundations of reasoning ended here, all knowledge would be limited to historical recordings of single causes and their respective effects. Nothing could be known that had

1. Harmon, Francis L., <u>Principles of Psychology</u>, The Bruce Publishing Co.: 1938-40, IV, page 370.

not been directly experienced, and predictions of the future would be entirely impossible.

The second fundamental law here applicable, the Uniformity of Nature, asserts that nature operates in ways that are universal. That is, whatever essentially causes a particular effect will, by virtue of the universality or uniformity of nature, essentially cause that same effect whenever and wherever it appears. If, therefore, the essence of a particular cause-and-effect relationship can be ascertained, it can be assumed, or predicted, to occur in like manner whenever these essential conditions are met, and knowledge itself becomes extended ". . . without the mediation of perception."

Philosophers have traditionally differentiated between two methods, or approaches, to this process of reasoning -- deduction and induction. Deduction occurs when thinking proceeds from a general, universal rule to a specific instance falling under that rule. "It proceeds from the universal to the particular, from the simple to the complex, from the logical whole to the logical part, from the general law to the individual case, from the cause to the effect."[1] It is concerned with the "formal truth" of the reasoning process, or the validity of the conclusions drawn from the given premises. It is by nature, a synthetic process.

1. Bittle, Celestine N., O.M.Cap., Reality and the Mind: Epistemology, The Bruce Publishing Co.: Milwaukee, 1936, page 7.

Induction, on the other hand, proceeds in the opposite direction. From particulars or a group of specific instances to a pattern or theory governing them, it ". . . is the legitimate inference of universal laws from individual cases."[1] It is concerned with the "material truth" of the reasoning process, that is, the validity or truth of the factual statements comprising the premises. It is analytic in nature.

But the process of induction poses still another problem. To derive a general rule from an examination of specific instances would seem to require an exhaustive examination of all the possible instances that might be included under that general rule. Whenever this can be done the resulting rule is said to be the product of complete induction. This rule, however, becomes an end product. There is no way for it to contribute to new knowledge, for everything subsumed under it that is knowable must have already become known in the process of arriving at the law itself.

It can readily be seen that such a complete examination is almost always impossible. In such a case, it becomes necessary to establish so-called general rules on the basis of only partial examinations, or incomplete induction. The certitude of the complete induction becomes replaced with varying degrees of probability. Because of the uniformity of nature, discussed

1. Bittle, Celestine N., O.F.M.Cap., The Science of Correct Thinking: Logic. Bruce Publishing Co.: Milwaukee: 1950, page 297.

earlier, it has been found that, as that which becomes known from the examination of a group of particulars more closely taps their essence and nature, the probability of that particular law becomes increased.

Incomplete induction, then, can easily be recognized as a most important approach to any form of organized and systemized, or "scientific" thinking. In fact, when certain requirements are fulfilled that show the conclusions to be legitimate, incomplete induction becomes "scientific method" or that process which "aims to discover what the facts really are."[1]

Among these requirements for scientific method are the recognition of the universality of qualities and traits forming the essence and nature of each thing, as well as the following of these five distinct but interrelated steps:

1. Observation of facts
2. Formation of hypothesis
3. Proof or verification of hypothesis
4. Explanation of the law
5. Application of the law

An inquiry, or question, is felt and formulated. On the basis of past knowledge and experience one or more hypothesis or guess as to the probable cause of the effect under observation is established. The hypothesis is tested, usually through observing a

1. Cohen, Morris R., and Nagel, Ernest, <u>An Introduction to Logic and Scientific Method</u>. London: 1934.

sample of the phenomenon under question and determination is made of which hypothesis is in best agreement with the facts. Again, as sampling and knowledge gets closer to nature and essence rather than attributes, the need for further evidence decreases and its probability increases. The "law" so derived is stated and explained and is then ready for application to similar instances, for prediction or additional verification. Scientific method then, ". . . is concerned with verification. . . . (It) is the only way to increase the general body of tested and verified truth and to eliminate arbitrary opinion."[1]

Although induction and deduction have been described as separate forms of reasoning, a closer look at these steps of scientific method reveals that they are both, in actuality, but different aspects of a single, combined process of formal logical reasoning or inference. Once a general law is established by analysis, or induction, it is useless and meaningless unless applied through synthesis, or deduction.

Logicians and other philosophers have not been alone in their concern for the process of reasoning. From almost every field have come urgent pleas to apply these techniques of reasoning and "scientific method" more conscientiously. From the field of education, J. Miles asks that students be trained to think and write with reason, that is, more than a mere reporting of facts but not totally creative and unsubstantiated either. She

1. Cohen and Nagel, Ibid. page 401

urges ". . . the making of statements based on interest and speculation and the supporting of them by adequate evidence pro and con."[1]

Gombrich, in the world of art, says, "All culture and all communication depend on the interplay between expectation and observation, the waves of fulfillment, disappointment, right guess and wrong moves that make up our daily life."[2]

In the domain of English, Brown says, "Any collection of objects or events is susceptible of a large number of alternative categorizations -- exclusive, conjunctive, disjunctive, or relational."[3] "By experiment we discover expectancies linking categories or variables."[4]

Speaking from the standpoint of history, Teggert says: "Consciously or unconsciously, all facts observed and set down have relation to some notion, hypothesis or theory. . . . Actual scientific inquiry begins, not with 'learning' what is already known of a particular subject, not with the collection of materials, but with the perception of some difficulty in the current

1. Miles, Josephine, "The Use of Reason." Teachers Coll. Rec., 1962, 63 (7), pages 540-547.

2. Gombrich, E. H., Art and Illusion. Pantheon: New York, 1960, page 60.

3. Brown, R., Words and Things. Free Press: Glencoe, Ill., 1958, page 13.

4. Ibid. page 342

explanation of phenomena. What ensues upon the perception of a difficulty is sustained cogitation."[1]

The field of psychology has been just as acutely aware of the need to exercise proper reasoning in its deliberations, but it has gone even further. As "the science of the mind and mental activities,"[2] psychology has also been concerned with those mental processes or activities of cognition, or thinking, employed in reasoning itself.

In attempting to investigate the nature of intelligence, Charles Spearman became one of the first psychologists to discuss the cognitive process. Psychology was at that time, he felt, a "chaos." To be a science, it must have a set of universal laws or principles. Drawing upon the results of the vast amount of individual research already done, Spearman developed the three principles of cognition which have since come to be viewed as the classical psychological approach to this process of arriving at knowledge.

All knowledge, infinite in range, according to Spearman, is based on individual persons' experience which may be divided into two levels. The first, entitled sentience, is the the primary effect of sensory stimulation. It is purely a mental

1. Teggert, F. G., Theory and Process of History. University of California Press: Berkely, 1950, page 164.

2. Morehead, Albert and Ray, editors, The New American Webster Handy College Dictionary. The New American Library, New York: 1961, page 367.

state involving an experience or reaction merely lived through or undergone. As soon as even the most basic form of intellectualization is made concerning any such experience, cognition appears and a percept, connoting far more than the mental state alone, is formed. These principles of cognition apply therefore to percepts.

1. The Apprehension of Experience -- "Any lived experience tends to evoke immediately a knowing of its characters and experiencer."[1] Functioning here as a unit are three levels of awareness -- awareness of the experience itself, awareness of knowing the experience, and awareness of the self as the knower of the experience. Characters, that is, the experiences themselves, may be in the realm of affection (sensory and non-sensory), cognition (knowledge of) or conation (feeling about). This first principle, postulating the awareness of experience and the self as the experiencer, is primarily concerned therefore with the states and acts of the experiencer.

2. Eduction of Relations -- "The mentally presenting of any two or more characters (simple or complex) tends to evoke immediately a knowing of the relation between them."[2] Once aware of two or more characters, or experiences, the intellect connects elements together and becomes aware of the relation between them.

1. Spearman, Charles, The Nature of "Intelligence" and the Principles of Cognition. MacMillan & Co., London: 1923, page 48.

2. Spearman, Ibid. page 63.

These experiences may be either actual (perceptual) or merely presented (conceptual). The relation, once generated, can then become a character in itself. This second principle adds all humanly cognizable relations and can be thought of as that process inherent in the discovery of rules.

3. Eduction of Correlates -- "The presenting of any character together with any relation tends to evoke immediately a knowing of the correlative character."[1] Applicable only when the second principle is, this third leads to the same eventual result, differing only in which items are presented initially and which arise in the process. Here, the awareness of a character, or experience, and a relation leads to the a wareness of other characters having the same relation which need not, in themselves, be actually experienced. Only in this way can there be awareness of characters outside personal experience. This third principle which adds all possible correlates to the relations of the second principle is used whenever scientific laws, practical methods, or maxims are applied.

Spearman's second principle, the evoking of a relation, or general rule, from two or more characters, or specific instances, has often been considered inductive in character while his third principle, the application of a relation to other characters not directly experienced, has been said to be deductive. Spearman himself said that these second and third princi-

1. Ibid. page 91.

ples, were parts of the same process just as the philosophers said of induction and deduction, and in a later work in collaboration with Jones he suggested a modern theory of cognition characterized by the word NOEGENESIS, coined from the Greek words NOUS and GENESIS, and used to ". . . designate creation of knowledge in its two chief forms, the eduction of relations and the eduction of correlates."[1] Noegenesis combined with abstraction, they said, clearly defined the nature of "G" or general intelligence.

It is the hope of this present study to investigate experimentally one small segment of this process of cognition, or the acquirement of knowledge. An attempt will be made to discover whether or not there appears to be any relationship between age, as indicated by grade placement between the third and eighth grades inclusively, and the ability to reason inductively, or make discoveries.

The instrument to be used is a number-series test in which it is necessary to examine groups of numbers, discover the appropriate governing rule and complete the series with the next proper numbers. Although designed to measure induction, or the ability to discover rules, it is apparent that whether or not these rules have been accurately abstracted can be determined only when they are reapplied and the series either correctly or

1. Spearman, C., and Jones, L. Wynn, Human Ability. London: 1951, page 65.

incorrectly continued. It will be necessary therefore to rely on deduction for measurement and the question might well be raised whether the results to be obtained can be applied to the inductive process alone or should in fact be ascribed to general reasoning, involving <u>both</u> induction and deduction.

CHAPTER II

REVIEW OF LITERATURE

Before induction, or any mental process for that matter, can be studied experimentally, it must first be capable of being isolated. In 1933, Charles I. Doyle, S.J. designed an original multiple choice, self-recording keyboard with which his 31 subjects were required to cause a bell to ring in as few strokes as possible. When instructed to observe "scientific method," that is, alert observation, accurate notes, and the distinction between hypothesis and observed fact, there was a significant improvement from the uninstructed performance. He concluded that the instructed performance was governed by thought, setting inductive discovery apart from trial-and-error learning.

On a more monumental scale, Thurstone and his associates in 1932 applied his method of factor analysis to a number of tests supposedly measuring intelligence. His now classical results suggested the isolation of eight factors, or primary mental abilities, among them inductive reasoning which he described as the ability to solve logical problems, to foresee and to plan. This, he said, was the most important of all the primary mental abilities (PMA). When first published in test form some years later, after continued study, these PMA were reduced to six which still included a reasoning factor, thought to be inductive in nature and found in tasks requiring the subject to discover the rule or principle governing the material of the test. To this day, a reasoning subtest is still included in the two upper age levels of Thurstone's Primary Mental Abilities Tests.

In a rather complicated study in which he admitted a number of factors to have been uncontrolled, including the introspection of untrained subjects, Burack investigated mental processes inherent in several kinds of reasoning, including induction. He found induction to be characterized by 100% use of a preliminary study of all aspects of the presented problem, 70% use of analysis into major variables, and only 40% use of clear formulation of the problem. He concluded that the number and kinds of methods used in solving reasoning problems depends on the kind of problem involved. Based, in part, on Burack's results, Olga McNemar tried to differentiate persons of high and low reasoning ability. Her study essentially confirmed Burack's results, as well as indicated that good reasoners might be characterized by superior processes and speed of induction.

Even the most cursory review of literature on the isolation of inductive reasoning reveals an interesting, sometimes almost heated, and still continuing controversy between those advocating a number of distinctly separate but interacting abilities and the adherents of a single factor of general intelligence acting in all functions of human life.

Charles Spearman, who had already suggested the existence of a general factor of intelligence which he designated "G," was one of the first to argue with Thurstone's multi-factor theory. He denied the existence of any specific factor described by any term as induction and insisted that any tests so named were in reality measuring "G" or general intelligence. As might be expected, Thurstone retaliated by claiming that Spearman's tests for "G" were in truth inductive in nature.

The Thurstones continued their attempts to further investigate the nature of the primary mental abilities and at the same time purify their tests by trying to reduce still further the number of primaries involved in each. By 1941 they said: "The inductive factor was again identified in the old and in the new tests that were specially constructed for this factor, but the tests for induction did not have so high a validity as the tests for the more definitely identified factors."[1] They were nevertheless confident it did exist and that it deserved inclusion in their tests for PMA. Noting that induction obtained the highest correlation of all the primaries with their second-order general factor, they tentatively suggested it might be the "much-debated" general-intellective factor of Spearman. Further in the same study they urged that the "inductive factor needs further study to clarify its nature."[2] By 1957 Thelma Thurstone,

1. Thurstone, L. L. and Thelma G., Factorial Studies of Intelligence, Psychometric Monographs No. 2. Chicago: 1941, page 1.

2. Ibid. page 27

reviewing their almost 20-year work on the PMA, identified the presence of two reasoning factors, induction <u>and</u> deduction. She said they could not be measured entirely separately no matter how hard it had been tried, as deduction was always necessarily present as a device to measure induction. She repeated the Reasoning factor's highest correlations with other factors and again suggested it may be Spearman's "G."

Several studies have been done on the stability of the various PMA subscores. On the Induction test, Traxler obtained test-retest correlations of +.578 between the 9th and 10th grades, +.731 between the 10th and 11th and +.758 between 11th and 12th. He generally concluded considerable but not exceptional stability in the PMA over a year's time.

Meyer and Bendig administered the Intermediate form of the PMA to 100 eighth graders and again as they were finishing eleventh. Correlations on R between these grades were +.76 for boys, +.71 for girls and +.75 combined or +.81, +.76 and +.81 respectively when corrected for attenuation. He concluded a high degree of consistency among PMA between these grades.

Since the controversey appeared, many factorial studies have been done on the nature of reasoning with varied results.

Adkins and Lyerly obtained scores on 66 variables from 200 Army men. They felt they failed to confirm a general reasoning factor but did identify five reasoning factors, three of which they thought to be inductive in character:

Factor A' - Perception of Abstract Similarities,

Factor B' - Hypothesis Verification, and

Factor M' - Concept Formation

Using 21 test items, Corter extracted eight reasoning factors of which he identified all but one. His No. 5, Concept, he felt was not too well established but appeared to involve recognition, abstraction, generalization and inductive thinking.

Matin and Adkins, in 1954, obtained inter-correlations among 13 first-order factors yielding six second-order factors. Their Factor IV, Speed in Analysis, included their first-order factors Number, Perception of Abstract Similarities, Perceptual Speed, and Space. They suggested that a fundamental ability common to all these factors was most plausible, probably an analytical ability.

A side effect of a longitudinal study of the PMA by Meyer and Bendig, already mentioned, revealed large correlations between factors suggesting to the authors that the structure of intelligence does not consist of independent traits but shares a common source of variation.

Kettner, Guilford and Christensen conducted a rather complicated series of studies designed to explore abilities considered important in the successful performance of high level personnel. The earlier of their studies suggested the existence of a general reasoning factor and later studies attempted to clarify its nature ending in 1956 with a ". . . concentrated study of a factor that has been relatively easy to isolate and cross identify in factor analytic studies but difficult to define."[1] They used 23 tests designed to tap their three hypothetical definitions, ie, 1. Defining problems, 2. Handling complicated procedures, and 3. Trial and error manipulation, as well as five reference factors including eduction of patterns. Ten factors were isolated and nine identified, of which five were the reference factors. The remaining four included a mathematical achievement factor and one for each of their three hypotheses. On the basis of these results and those of previous studies, the authors identified, by the process of elimination, their Factor F, Defining problems, as the best description of general reasoning--". . . has something to do with comprehending or structuring problems in preparation for solving them."[2] They urged further research to define the scope of this factor and suggested that general reasoning involves the grasping of patterns where conceptional relations are featured and that in this case it would parallel the factor <u>eduction of patterns</u>.

Perhaps the most pertinent factor analytic study was done by Rimoldi when he tried to investigate directly the unitary nature of Spearman's "G" and its possible relationships to

1. Kettner, Norman; Guilford, J. P., and Christensen, Paul R., A Factor-Analytic Study of the Factor Called General Reasoning: <u>Educ. Psychol. Measurement</u>, 1956, 16, 438-453, page 449

2. <u>Ibid</u>., page 449

Thurstone's factors I (Induction), R (Reasoning) and D (Deduction). In all, he used 25 tests of "G", I, R and D with 384 children between the ages of 11 and 14. He extracted seven first-order factors, including the eduction of relations (Spearman's second principle), the eduction of correlates (Spearman's third principle) and the eduction of likeness and its opposite, and three second-order factors. These three he described as:

α Relation of likeness--basic step in solutions of intellectual problems

β Logical processes underlying intellectual activity, and

γ Concrete psychological performances of synthesizing nature. He identified factor α with "G" as all high-loading tests involved Spearman's concept of noegenesis and abstraction. Since <u>all</u> tests used were heavily loaded with Thurstone's I, R and D, however, he felt this to be sufficient grounds to believe them related to "G" and concluded that "G" is non-unitary in nature.

Factorizations in the course of Rimoldi's study suggested that arithmetic ability involved functions other than the manipulation of numbers. Picking up this concern in a Ph.D. dissertation, Sister Mary Canisia Majewska attempted to explore the domain of mathematical ability in general and, in particular, study the nature of numerical and reasoning factors that seemed to enter into mathematical ability. She administered 36 selected tests to 150 eleventh grade girls. Twelve first-order factors were isolated including Factor J--which she identified as eduction of correlates. High loading tests were those Spearman described as "G" and Thurstone as I or those in which ". . . the relationship is not given explicitly, but once it is discovered, the response may be the eduction of a correlate . . ."[1] Among four second-order factors was Factor C' identified as probably representing abstraction and characterized by tasks which ". . . require ability to educe and manipulate relations of all kinds."[2]

An interesting aspect of this controversey appeared when Wrigley, Saunders and Neuhaus compared the results of Thurstone's original work as analyzed according to a variety of factor analytical methods including their own Quartimax method, Thurstone's simple structure, Zimmerman's revised structure, Holzinger and Harmon's bi-factor analysis and Eysenck's group factor analysis. The Inductive factor was isolated only by Thurstone who called it Induction and Zimmerman who called it General Reasoning. In the Quartimax method, the verbal factor merged with the general factor, losing its separate identity and becoming the General-Verbal factor. They concluded "The Quartimax results did not fully agree with either side in the celebrated dispute about the general factor but represent a midway

1. Majewska, Sister Mary Canisia, C.S.F.N., <u>A Study of Mathematical Ability As Related to Reasoning and Use of Symbols</u>, Unpublished Ph.D. Dissertation, Loyola University, Chicago, 1960, page 40.

2. <u>Ibid</u>., page 46

position."[1] The authors felt that further development of analytic methods should eventually solve the controversy between protagonists of simple structure and of the general factor.

But whatever it is named, the ability to generalize from particulars to universals clearly does exist and it appears to be almost universally accepted that it is a developmental phenomenon becoming more fully defined and increasingly stable with age and maturation.

Just about every book written in general or educational psychology or child development devotes at least brief and sometimes intensive consideration to the processes of reasoning and their maturation. Sully, back in 1915 and Fox in 1951 state that inductive reasoning, or discovery, begins naturally in the infant as he begins to make sense out of the vastness of the world around him. Gradually, through repeated observations, comparisons and groupings or classifications are formed which enable him to recognize and name new objects and, eventually, ideas, because of his own past experiences. Younger children tend to expect too much similarity in things and may generalize from an inadequate range of observations. As experience widens and intelligence advances the points of diversity as well as uniformity are more clearly noted and more pains are taken to

1. Wrigley, Charles; Saunders, David R., and Neuhaus, Jack O., Application of the Quartimax Method of Rotation to Thurstone's Primary Mental Abilities Study: Psychometrika: 1958, 23, 151-170, page 155.

limit conclusions. Fox says, "Since it is more concrete, inductive reasoning is often simpler for a child, and in its elementary forms, such as the elimination of alternative hypotheses, is well within the competence of a child of eight years."[1]

Vinacke, in his discussions of children's abilities, their development and measurement, goes even further. He says, "Children, during the school years possess basically the same abilities which characterize older children and adults," making clear that he is ". . . not stating that children of all ages can do the same things, but rather that they can do the same kind of thing."[2] Whenever children of different ages have been investigated, it has been found that ability to deal with different kinds of tasks improves as the child gets older. This result occurs in all sorts of situations,"[3] including reasoning. Rate of increase varies, he says, in three ways: 1. Different children show different rates of increase in the same ability; 2. Different abilities increase at different rates; 3. The same ability grows at different rates at different ages. Reasoning at six years, he says, is in the form of rather disorganized and subjective problem solving behavior with difficulty discovering and stating principles. By twelve, however, it seems much

1. Fox, Charles, <u>Educational Psychology</u>. New York: 1951, page 346.

2. Vinacke, W. Edgar, Intelligence Tests and Children's Abilities, <u>Education</u>: 1957, 77, 421-426, page 424.

3. Vinacke, W. Edgar, Developmental Changes in Thinking, <u>Education</u>: 1957, 77, 318-322, page 319.

easier to learn principles required to solve problems. Behavior is relatively mature, organized and adapted to the requirements of the task.

Piaget, in his numerous studies in the development of logical thinking theorized that thinking could be identified with verbal expression and differed by nature from one developmental stage to the next. Hazlitt took exception and postulated that children's thinking differed from adults by degree and not by nature. She found experimentally that abilities and verbalizations differed in matter of degrees with age and intelligence and that ability itself appeared before verbalization of it. She concluded there was ". . . no age limit in relation to the processes of thinking, beyond that imposed by lack of experience."[1]

Heidbreder asked groups of three, four, six to ten year olds and adults to find a hidden object in a variety of simple to complex situations and explain how they knew where to look. "Both quantititave and qualitative results indicate that the response of giving reasons is one which develops through the years; that there is an increase in the readiness with which it is elicited; that there is a progressive change in the forms it assumes; . . . that there is a growth or development . . . so often found in the development of other complex organic processes."[2]

1. Hazlitt, Victoria, Children's Thinking, British Journal of Psychology, 1930, 20, 354-360, page 360.

2. Heidbreder, E. F., Reasons Used in Solving Problems, J. of Exp. Psych., 1927, 10, 397-414, page 411.

To test reasoning as opposed to learning in young children from three to eight, Maier set up a maze situation in which it was necessary to build upon certain controlled experiences in the maze itself to reach a certain goal. He concluded that while the ". . . ability to re-organize past experiences to form new combinations is independent of the ability to form associations"[1] the latter matures earlier and the ability to re-organize appears later, rarely under six.

Osler and Fivel attempted to investigate the effect of age and intelligence on concept formation by induction. They asked subjects to find a hidden marble on the basis of matched pictures involving various concepts. They found no difference in concept hierarchy but significant increasingly better performances among the six, ten and fourteen year olds of their test population.

Perhaps the single test used most extensively in the study of ability development patterns has been Thurstone's Primary Mental Abilities. In a pair of similarly designed studies on stability patterns of the PMA, Tyler administered tests at the first, fourth and eighth grade levels and Meyer at the eighth and eleventh grade levels. Their pooled results indicate only chance relationships between test-retest scores at the first and fourth grade levels but between the fourth and eighth clear consistency for the Verbal, Number and Spatial factors but not for Reasoning,

1. Maier, Norman, Reasoning in Children, Journal of Comparative Psychology, 1936, 21, 357-366, page 365.

which Tyler interpreted as being not yet unitary but representative of several separate reasoning factors. Meyer found a correlation of +.75 between eighth and eleventh grade R subtest scores. They concluded jointly that there is increasing stability as well as differentiation of the various PMA with age.

Investigating sex differences among the PMA, Hobson found that eighth grade boys obtained a R subtest mean of 27.16 and standard deviation of 8.49 while ninth graders a mean of 29.65 and S. D. of 7.88. Eighth grade girls obtained a mean of 30.44, S. D., 8.21 and ninth graders a mean of 32.98, S. D. 8.85. This indicated, he felt, that R increases in both boys and girls.

Reasoning, specifically inductive reasoning, has been investigated and measured in a number of ways but the one that appears most often seems to be any variation of the number or letter series test. Numbers, sometimes letters, or both, are so arranged as to be governed or controlled by a general rule or principle. The required task is to examine the arrangement and from the specific clues derive, if possible, the appropriate rule, then re-applying the rule, complete the series with one, two or three numbers (or letters) usually at the end of the given series but very occasionally in the middle.

Fox related the number series test directly to Spearman's third Principle of Cognition, the Eduction of Correlates. "Given the series, 2, 4, 8, 16, 32, ___, ___, ___, it is obvious that the relations between these fundaments is that of geometric progression, and, therefore the succeeding fundaments are determined."[1] Spearman himself was so impressed with the results of a number series test in trying to discover Noegenetic tests to measure "G" that he suggested everything else be dropped and it used alone.

At any rate, it seems to be almost a universal assumption that induction can be measured by number or letter series--so much so that any study of reasoning, logical thought processes or intelligence seems to include almost invariably at least one of these types. The factorial studies mentioned earlier on the nature of intelligence or reasoning by Adkins and Lyerly, Kettner, Guilford and Christensen, Rimoldi, and Majewska all included at least one form of these series completion tests, sometimes admittedly as reference tests for the reasoning or induction factor. Burack also used letter groupings as one of his specific tests for induction.

Thurstone included number and letter series tests in his famous original study of the Primary Mental Abilities. They continued to appear as Induction or Reasoning tests in subsequent PMA test revisions and are still present in the eight - eleven and eleven to seventeen year old forms used today. The Kuhlmann-Anderson Tests of intelligence also contain an Induction subtest including number series.

Agnes Rogers was apparently the first to use number

1. Fox, Charles, Op. Cit., page 284.

series in a sextet of tests designed to: 1. analyze numerical or symbolic data; 2. perceive the general rule implicit in them; 3. apply the principles so derived. She used 12 number series, each consisting of four numbers with a blank space in the middle involving the four common processes. Reliability coefficients for her two applications of this test to each of two schools were +.75 and +.70. Her Interpolation test included 40 items of varying lengths and degrees of difficulty. Items were groups of numbers with anywhere from two to ten empty spaces to be filled by some combination of addition. Reliability coefficients for this test were +.71 and +.94.

In 1917, the American Psychological Association appointed a committee headed by Robert Yerkes to set up the now famous Army Alpha and Beta tests to classify U. S. Army recruits and draftees in World War I. After considerable experimentation and revision by F. L. Wells and his associates, the Rogers' missing numbers tests became the Number Series Completion test, test #six of the Alpha form. The first revision of the examiner's guide listed coefficients of correlation of the seven other Alpha tests with Induction, or number series, ranging from +.61 to +.77 and +.84 with the total test scores.

Investigating sex differences on Army Alpha scores at the secondary school level, Whipple reported that freshman boys and girls obtained median scores of 9.73 and 8.94 respectively while senior scores were boys, 10.80 and girls 9.92.

Schneck administered nine tests to 210 college men, aged 18-21 to assess measurement of verbal and numerical abilities. Among his tests for numerical ability he included a 40-item number series test, four taken from the Army Alpha and the rest his own design. The highest coeffecient of correlation for the number series test was with arithmetic reasoning and was +.92. Number series correlated +.46 with the whole numerical division of the battery.

As part of a series of "Planning for Life" tests, G. B. Baldwin designed the Inductive Reasoning Test as a high school screening device for mathematics classes. It consists of a 40-item, multiple choice number series test scaled and arranged in order of difficulty. Validity coefficients of correlation, obtained between test scores and teachers' ratings, ranged between +.52 to +.85, averaging +.62. An odd-even reliability correlation was +.93. The first 32 items were found to discriminate highly with high school freshmen and the last 32 with seniors. The first eight were so easy for seniors as to be virtually practice items and the last eight too difficult for most freshmen.

The United States Employment Service (USES) test includes a number series subtest which, in a study by Mouly and Robinson, comparing USES with PMA, obtained the highest correlations of all with the PMA Reasoning subtest, +.65 for tenth graders and +.68 for twelfth graders.

The Holzinger-Crowder Uni-Factor Tests were designed as an ability battery for guidance purposes at the junior and senior high school levels. The Reasoning subtest, R, making no attempt to differentiate induction and deduction, includes a mixed series (letters and numbers) test. Reliability coefficients on R are reported to be for alternate forms (AM and BM), +.827 and split-half, +.933.

The Loyola Induction Study, a number series test, was conceived and devised in the late 1950's by Charles I. Doyle, S.J. of Loyola University, Chicago. Several studies have been done on it since.

Mary McNeill included the Loyola Induction Study (LIS) in her battery of tests to investigate the relation between deductive and inductive reasoning ability and adjustment in adults. Her population included 100 bright junior and senior high school males mostly interested in science and 80 male and 20 female graduate and undergraduate university students mostly interested in industrial relations. On the LIS the high school students obtained a mean score of 45.62 with a standard deviation of 9.22 while the university students obtained a mean of 37.62 and standard deviation of 12.57. This difference was found to be significant at the .01 level of confidence. She concluded that the higher high school mean represented an accelerated group of superior intelligence suggesting that inductive ability is closely related to intelligence.

A pair of similar studies compared performance on the

Loyola Induction Study of junior and senior science vs. humanities majors in college. Ortolani studied 128, 64 in each group, Loyola University male students and Forst worked with 128 equally divided Mundelein College women students.

The science majors in Ortolani's study attained a mean of 44.5 and standard deviation of 10.7 and the humanities a mean of 39.8 and standard deviation of 10.6. The difference in favor of the science majors was significant at the .02 level of confidence. When matched for intelligence, however, on the basis of ACE scores, the science group's mean was 44.39, standard deviation 9.7 and the humanities mean was 42.48, standard deviation 10.2. This difference was not significant. When matched on the basis of grade-point averages the science mean and standard deviation were 45.19 and 9.74 and the humanities were 38.09 and 11.33, the difference being significant at the .02 level of confidence. He concluded inductive reasoning to be characteristic, but not exclusively so, of science students. Persons with high inductive ability should be urged to enter science, he said, while those with lower inductive ability should be guided into other fields.

The women science students in Forst's study obtained a mean of 43.59 and standard deviation of 10.41. Her humanities group scored 35.73 and 8.35 respectively and the difference between these groups was significant at the .001 level of confidence. LIS scores of the science group correlated +.726 with the

Q and +.378 with the L subtests and +.592 with total scores of the ACE tests. Humanities correlations were +.371 for Q, +.394 for L and +.545 for total scores. Scholastic achievement as indicated by grade-point averages correlated +.317 for the science group, +.473 for humanities and +.491 for both groups together. Forst concluded that upper division Science students are superior to Humanities students on the LIS, also that there is a positive relation between performance on the LIS and scholastic ability as measured by ACE and that there appeared to be a high relationship between Q ability on the ACE and inductive ability.

In the most similar study to the one here undertaken, Sister Mary Colomana Buksa administered the original 42-item version of the Loyola Induction Study to 400 children between the fifth and eighth grades with the following results:

GRADE	MEAN	ST. DEV.	DIFF. SIG. AT ___ LEVEL OF CONF.
5	13.34	7.44	
			.001
6	16.70	5.91	
			.05
7	18.98	8.04	
			.001
8	23.30	1.17	

She concluded simply that inductive reasoning develops with age and maturation and can be measured reliably with the Loyola Induction Study.

CHAPTER III

PROCEDURE

The Loyola Induction Study, having been lengthened by its creator, Rev. Charles I. Doyle, S.J., from its original 42 items to 62 items and subsequently scaled and revised in order of increasing difficulty in unpublished work by the author, was administered to 1085 third to eighth grade pupils of 12 Chicago area public and parochial schools selected at random. Table I includes these specific grade level populations. (For a complete listing of all contributing schools and grade-level breakdown, see Appendix C.)

Table I

Populations of Grade Levels Three Through Eight

GRADE	N	GRADE	N
3	119	6	373
4	179	7	376
5	263	8	338

The tests were administered in the regular classrooms, usually by the classroom teacher, sometimes by the principal or teacher in charge of the school's testing program. Each was first instructed in the directions for administering this test in order to insure uniformity of test procedures.

The test blanks (see copy in Appendixes A and B) were distributed one to each student, name side up with instructions to do nothing until directed. After filling in name, school, grade and favorite subject information, attention was directed to the specific instructions and four samples on the front page. Each was read aloud followed by enough pause to permit the individual to record his answers, but no further help or correction was given. Students were then told to turn to the first full page of test items, to answer as many as possible, and that there would be a prize for the one having the most correct answers. Work was stopped and test blanks collected at the end of exactly 20 minutes.

The 62 items of each individual test, including the four sample items, were checked for correctness of response. To be considered correct, it was necessary for all three blanks in a series to be properly answered. An individual score consisted of the number of series correctly answered. These individual scores were then tallied, or collated for each grade level.

The mean, standard deviation and standard error of the mean were computed for each grade level using the following formulae:

Mean: $$M = AO + \frac{i}{N} \sum d$$

Standard deviation: $$\sigma = \frac{i}{N} \sqrt{N \sum d^2 - (\sum d)^2}$$

Standard error of the mean: $$\sigma_M = \frac{\sigma}{\sqrt{N}}$$

Each grade level was then compared to its adjacent level by the computation of a standard error of difference using the formula:

$$\sigma_{diff} = \sqrt{\sigma_{M_1}^{2} + \sigma_{M_2}^{2}}$$

The significance of each difference was then determined by obtaining the critical ratio, or t-score by the formula:

$$t = \frac{M_1 - M_2}{\sigma_{diff}}$$

and checking it against the table of significances in McNemar's <u>Psychological Statistics</u>[1] to see whether or not the null hypothesis, in this case, "There is no difference in inductive reasoning ability as measured by the Loyola Induction Study from one grade level to the next," might be accepted or rejected.

1. McNemar, Quinn, <u>Psychological Statistics</u> (2nd edition) New York: 1957.

CHAPTER IV

TEST RESULTS

The distribution of individual scores for each grade level is presented in Table II, and in composite graphic form in Figure 3.

In Figure 3, some positive skewing is especially apparent in the frequency curves for grade three, to a slightly lesser extent for grade four and is still somewhat noticeable at grade five. This suggests a tendency of low scores to bunch at these grade levels while the higher scores taper off more in accordance with normal distribution expectations. The curves for the sixth, seventh and eighth grades more closely approximate normal distribution patterns.

Scores in the lowest interval, 0-2 correct, occurred at only two grade levels, the third with a fairly large number of eight, and one at the fifth grade level. The second interval, 3 to 5 correct, contained, again, rather large scores of nine at the third, thirteen at the fourth and nine at the fifth grade levels. The reader is reminded that the four samples were included in the scoring and that a score below four automatically indicates the failure of at least one of the sample items.

It would appear that for the third and fourth grades, and to some extent the fifth, test items were in general too difficult to differentiate sharply among low scorers. It may be

Table II

Distribution of Scores for Each Grade Level

SCORE	GRADE					
Intervals	3	4	5	6	7	8
0-2	8		1			
3-5	9	13	9	4	1	2
6-8	15	16	8	9	5	3
9-11	15	15	10	13	6	3
12-14	22	34	23	16	15	
15-17	21	30	48	51	30	7
18-20	15	28	39	56	46	19
21-23	9	23	42	59	48	20
24-26	1	8	35	52	48	46
27-29	2	6	20	47	58	48
30-32	2	4	13	29	35	50
33-35		2	9	17	43	43
36-38			5	9	14	34
39-41			2	7	14	19
42-44				1	7	13
45-47				1	3	8
48-50				1	3	12
51-53				1		7
54-56						3
57-59						1
60-62						0
Total	119	179	263	373	376	338

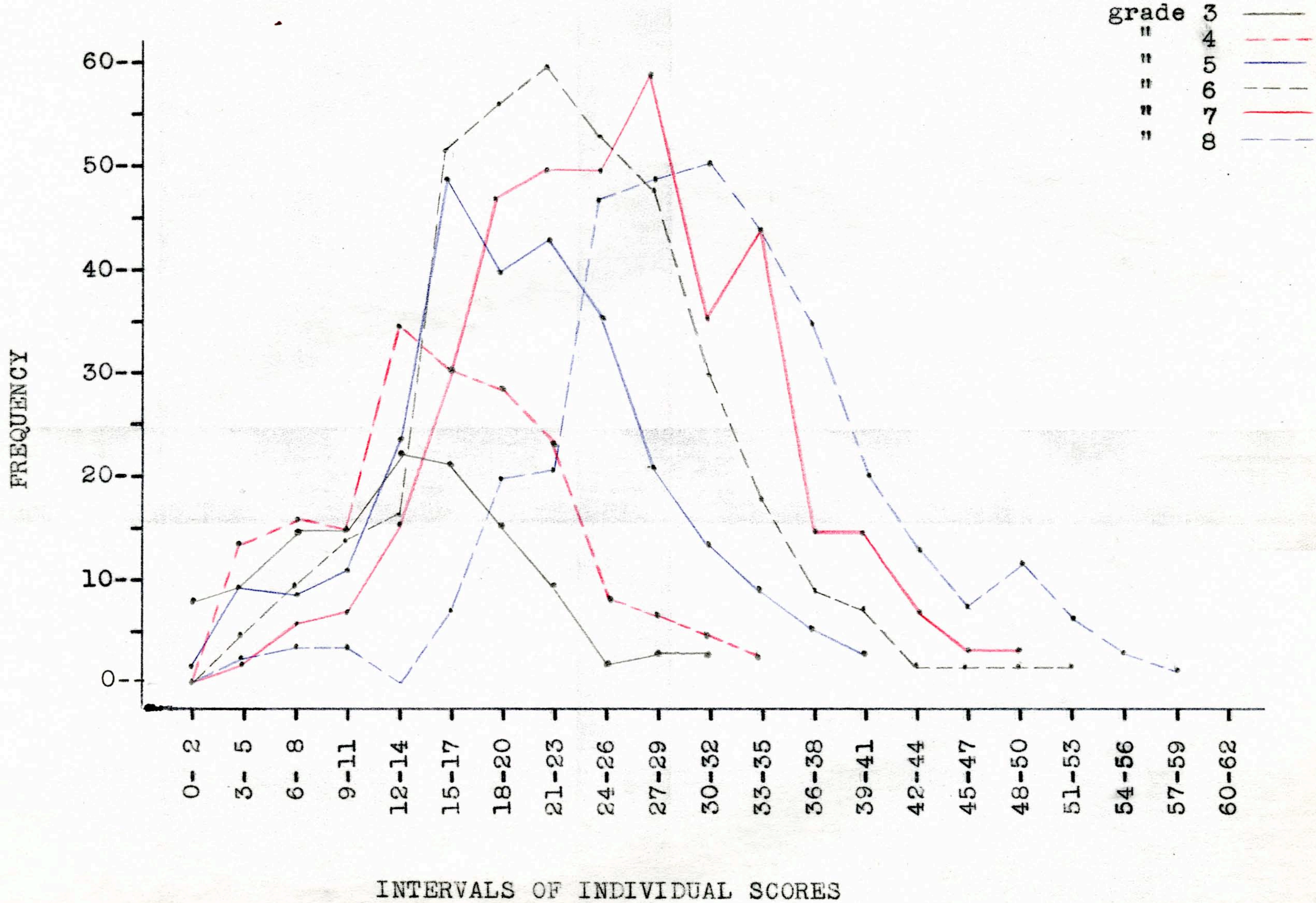

Fig. 3. Frequency Distribution Curves for Each Grade Level

that number concepts had not yet been adequately developed among this group or perhaps this test needs the inclusion of items still easier, if possible, than those already present. Skewness might also result from the smaller size of the third and fourth grade samples in comparison to those of the other grade levels. That is, larger samples might more closely approximate the normal distribution.

On the other hand, the literature seems generally agreed that while induction exists and functions within an individual since birth, the ability to deliberately isolate this process and apply it to a concrete situation or problem usually emerges somewhere after the age of six, and attains full maturity about twelve. It seems quite possible, therefore, that these bunchings of low scores may include a rather high percentage of children in whom this ability to deliberately think inductively has not yet emerged or developed to the level where it can be of significantly measurable practical use.

At the upper end of the range of scores, only one grade level contained scores beyond the 51-53 correct interval. At the eighth grade level, three scores were obtained in the 54-56 correct interval and one in the 57-59 correct interval. No scores were obtained in the 60-62 interval at any grade level indicating that this test was difficult enough to discriminate well among even the most proficient of the sample population.

While too difficult for some, who may represent a specialized group, this test was not too easy for any. With the possible exception of the low scorers in the third, fourth and perhaps fifth grade levels, the apparent approximation of the frequency distribution of the individual grade levels in this study to the normal curve, suggests that the results of these sample populations might be considered fairly representative of the general populations from which they were drawn.

Table IV contains a concise tabulation of all the statistical results obtained from analyses of these data.

Table IV

Statical Analyses of Data

GRADE	MEAN	ARITH. DIFF. BETWEEN MEANS	S.D.	ST.ER. OF MEAN	ST.ER.OF THE DIFF.	CR. RATIO	SIG. LEVEL
3	12.90		6.59	.600			
		3.10			.788	3.93	.001
4	16.00		6.84	.511			
		3.59			.675	5.32	.001
5	19.59		7.15	.411			
		3.07			.581	5.28	.001
6	22.66		7.30	.378			
		3.30			.531	6.21	.001
7	25.96		8.26	.373			
		5.78			.631	9.16	.001
8	31.74		9.35	.509			

The mean scores ranged from 12.90 for the third grade to 31.74 for the eighth grade with an almost even arithmetical progression from the third to the seventh grades. (See Figure 5.)

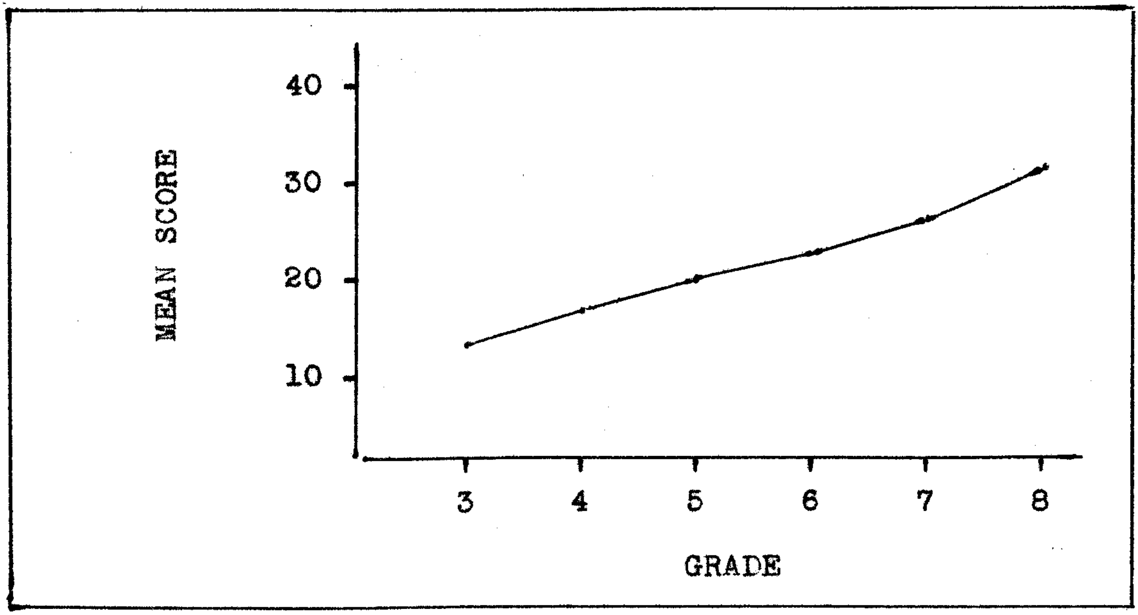

Fig. 5. Means of Each Grade Level

The arithmetical difference between adjacent grades, three to seven, ranged from 3.07 to 3.59. There was a much larger difference, however, between the seventh and eighth grades, namely, 5.78. Somewhere between the seventh and eighth grades, therefore, the ability to answer correctly number series problems seems to increase at a faster rate than at other levels.

It has already been mentioned that literature suggests that the ability to formulate and methodologically apply principles of inductive reasoning becomes relatively mature and well developed by about the age of twelve. Generally, this is the age span which covers the transition from seventh to eighth grades and may account, other than always possible sampling errors, for the apparent increase in development of reasoning ability at this level.

Standard deviations of each grade level (Table IV) consistently progressed from 6.59 for the third grade sample to 9.35 for the eighth grade sample, indicating increasingly wider ranges of test scores for each higher grade level, as expected if more children would be able to solve increasingly difficult items from one grade level to the next.

The differences between the mean scores from one grade level to the next, as expressed by their respective Critical Ratios, were all found to be significant at at least the .001 level of confidence. That is, there is less than one chance in one thousand that each of these differences could have occurred by chance.

The results of the present study are compared with Buksa's 1960 results in Table VI. It must be remembered that her results were obtained on the original 42-item, empirically scaled form of the Loyola Induction Study. In each case, the means for her fifth, sixth, seventh and eighth grade population are considerably below the means obtained in this present study (See Figure 7). In fact, they quite closely approach the respective means for the third, fourth, fifth and sixth grade levels of the present study.

Table VI

Tabular Comparison of Present Study With Buksa (1960)

	Present Study					Buksa - 1960				
GRADE	N	MEAN	ARITH. DIFF.	ST.D.	SIG. LEVEL	N	MEAN	ARITH. DIFF.	ST.D.	SIG. LEVEL
3	119	12.90		6.59		-	--		-	
			3.10		.001					
4	179	16.00		6.84		-	--		-	
			3.59		.001					
5	263	19.59		7.15		100	13.34		7.44	
			3.07		.001			3.36		.001
6	373	22.66		7.30		100	16.70		5.91	
			3.30		.001			2.28		.050
7	376	25.96		8.26		100	18.98		8.04	
			5.78		.001			4.32		.001
8	338	31.74		9.35		100	23.30		1.17	

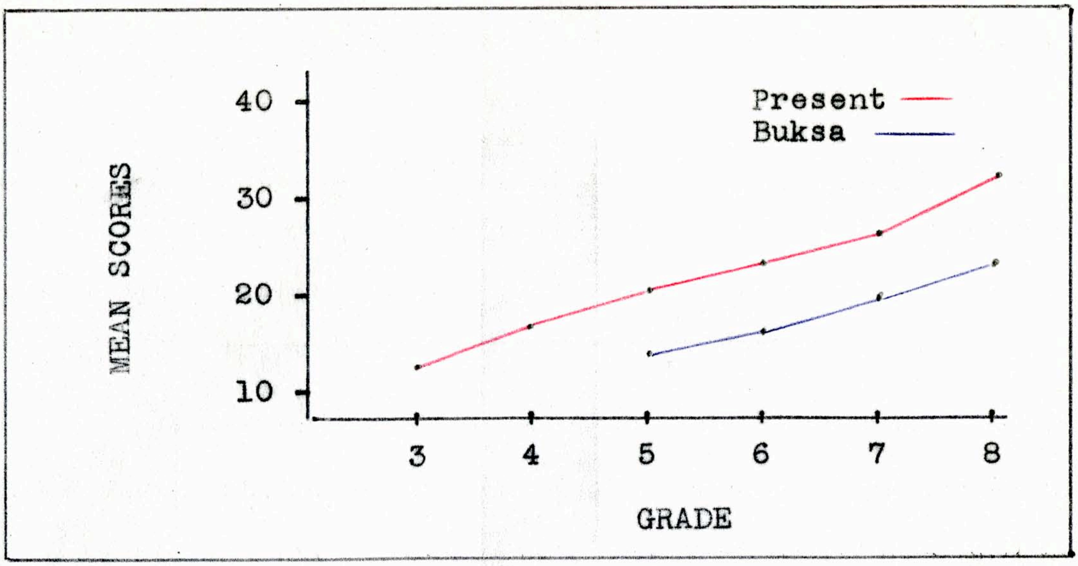

Fig. 7. Means of Buksa's 1960 Study and the Present Study

The differences between her fifth and sixth and seventh and eighth grades were, however, significant at the .001 level of confidence just as they are here. The arithmetical difference between her fifth and sixth grades is exceptionally close to that reported here but somewhat less for the sixth and seventh, and seventh and eighth grades. Interestingly, however, the amount of difference between each seventh and eighth grade group increased similarly in each study beyond that which would have been expected from the more regular increases of the preceding grade levels. This observation adds some weight to the previous suggestion that there seems to be an increase, or "growth spurt" in the continuing development of reasoning ability at this level, resulting perhaps, from the acquirement of more mature, logical approaches to problem-solving situations within this age range.

The lower means of Buksa's groups probably represent limitations in the original test. The subsequent addition of 20 items may well have provided increased sources for success. The statistically revised scaling in order of difficulty may be another important factor. During the work of revision iteself, it was discovered that a considerable number of items had been empirically misplaced. Thus, some harder items appeared fairly early in the test with relatively more easy ones appearing somewhat later. Getting "stumped" on the early hard items may have prevented or seriously handicapped later success. It seems possible that this phenomenon could account at least in part for the lowered significance (.05 level of confidence) Buksa obtained between her sixth and seventh grade levels which did not occur in this present study and which she could not explain other than possible sampling error. Going as far as these early hard items, students may have spent considerable time on them, virtually ignoring the rest, or perhaps, the failure on these affected later problem solving. The next level, however, succeeding more easily on these early hard items may have been able to go on succeeding enabling the difference between these next levels to again be highly significant.

Still another possible factor in these differences in means between this present study and Buksa's, might be that of motivation. Buksa's groups were asked simply to take part in a study of how people make discoveries. The present groups were promised a prize to the one in each class group achieving the highest score, always a highly motivating influence, especially among essentially competitive grade-schoolers.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary:

People from all fields of endeavor are raising pleas for the use of "reason," that is, the observation of facts, the formulation of a hypothesis based on those facts and the attempt to verify the hypothesis so derived. Psychology, no less concerned about the use of reason, has also been concerned with the processes of reasoning itself.

Philosophic tradition distinguishes between two forms of reasoning: Deductive, proceeding from the general law to the specific instance, and inductive, proceeding from a group of specific instances to a general law.

It was with the hope of exploring the ability to reason, or think, inductively at various grade-school levels that this present study was designed and conducted. The instrument used was the Loyola Induction Study, a number-series completion test in which it is necessary to examine a group of numbers and extract from them the principle or law governing the arrangement of numbers before the series can be successfully completed. It was expected, on the basis of available literature and research studies in psychology and education, that there would be a measurable increase in inductive reasoning ability, as measured by this test, from each grade level to the next.

The Loyola Induction Study was administered to 1648 third, fourth, fifth, sixth, seventh and eighth grade students from twelve Chicago area public and parochial schools selected at random. The differences between the means obtained at each grade level were in every case significant at the .001 level of confidence.

Conclusions:

1. There appears to be a highly significant increase in the ability to reason inductively, as measured by this test, between each grade level, three through eight, inclusive. The question might well be raised as to whether the ability being measured is strictly inductive or, since it is necessary to re-apply each generalization in a deductive manner to test the appropriateness of the generalization, it might be better to name it general reasoning or equate it with general intellectual functioning. Whatever it is precisely named, however, there is little doubt that this problem-solving ability becomes increasingly well developed with age and maturation.

2. The comparison of the results of the present study with those obtained in a similar study by Buksa in 1960 suggest the present lengthened and statistically scaled and revised form of the Loyola Induction Study to be a more discriminative, reliable and predictable instrument than its original form.

3. The bunchings of low scores among the lower grades of this study suggest the test (LIS) may be too difficult to discriminate adequately among poorer performances at these lower

levels. The validity of test scores below the third grade level might therefore be open to more serious question.

4. There appears to be a sharper increase in problem solving ability between the seventh and eighth grades than between any other grade levels. As indicated by the literature, this is about the age when inductive methods in problem solving approaches become relatively mature and well-developed, they may at this time be able to be applied with somewhat greater success than expected on the basis of continuing development alone.

5. Summarizing numbers 3 and 4 listed above, on the basis of this study, the ability to formulate and methodologically apply deliberate problem solving processes appears to begin somewhere but not much before the third grade, and develops rather consistently through the years until it reaches maturity somewhere around the seventh or eighth grades. The increase in ability to reason which appears beyond the eighth grade and on into adulthood might therefore be considered to be more a factor of increasing intellectual acuity, including the ability to grasp more abstract and complicated relations, as well as practice and refinement of the application of these problem solving processes than the continued development of the process itself. These implications may be extremely important to designers of tests to measure reasoning, especially when a single test is expected to serve both adults and children, as well as anyone attempting to establish age norms for this specific test (LIS). Much further

study of this apparent shift in the nature of increases in reasoning ability is needed before these implications should be seriously applied.

APPENDIX A
LOYOLA INDUCTION STUDY -- PAGES 1, 2 and 3

LOYOLA INDUCTION STUDY
Revised Edition

Name______________________________Date_______________

Student at____

Highest year of school completed (circle one)

6 7 8 9 10 11 12 13 14 15 16 __________

What is your favorite study or your major field?

____

INSTRUCTIONS

This is not an intelligence test. It is part of a study of how people make discoveries.

There are some easy examples below. Please read each row of figures and then write in the three blank spaces at the end of each row the numbers that should follow.

2	4	6	8	10	12	____	____	____
9	8	7	6	5	4	____	____	____
1	7	2	7	3	7	____	____	____
2	2	3	3	4	4	____	____	____

N.B. *Please* do not turn this page until you are told to do so.

APPENDIX B
LOYOLA INDUCTION STUDY -- PAGE 4

5	10	7	14	9	18	____	____	____
9	18	13	26	17	34	____	____	____
44	22	34	17	24	12	____	____	____
23	22	20	17	16	14	____	____	____
18	9	14	7	10	5	____	____	____
14	7	12	6	10	5	____	____	____
3	3	9	9	27	27	____	____	____
1	3	2	9	3	27	____	____	____
4	8	9	18	14	28	____	____	____
4	16	26	5	25	35	____	____	____
40	80	36	72	32	64	____	____	____
1	1	2	4	3	9	____	____	____
64	56	49	42	36	30	____	____	____
74	64	8	59	49	7	____	____	____
3	1	7	1	15	1	____	____	____
144	36	100	25	64	16	____	____	____
1	1	1	2	4	8	____	____	____
64	72	56	8	36	42	____	____	____
171	9	119	7	75	5	____	____	____
13	17	19	23	29	31	____	____	____

APPENDIX C

GRADE LEVEL DISTRIBUTION OF CONTRIBUTING SCHOOLS

Grade	School	School N	Grade Total N
Three			119
	Marconi	47	
	St. Ignatius	72	
Four			179
	St. Felicitas	43	
	St. Thomas More	33	
	Komensky	34	
	St. Ignatius	69	
Five			263
	St. Michael	30	
	St. Alphonsus	34	
	Smyser	47	
	St. Thomas More	38	
	St. Felicitas	47	
	St. Ignatius	67	
Six			373
	St. Felicitas	45	
	St. Alphonsus	35	
	St. Thomas More	35	
	St. Michael	18	
	St. Sebastian	36	
	Smyser	44	
	St. Ignatius	77	
	St. Adrian	43	
	St. Bride	40	
Seven			376
	St. Ignatius	45	
	St. Sebastian	52	
	St. Felicitas	46	
	Memorial Jr. High School	23	
	Smyser	52	
	St. Michael	29	
	St. Thomas More	31	
	St. Adrian	50	
	St. Bride	48	
Eight			338
	St. Ignatius	57	
	Smyser	41	
	St. Felicitas	43	
	Memorial Jr. High School	24	
	St. Michael	36	
	St. Sebastian	37	
	St. Bride	48	
	St. Adrian	52	

APPENDIX D

Distribution of Scores By Schools

THIRD GRADE			
Interval	Marconi (47)	St. Ignatius (72)	Total (119)
0-2	7	1	8
3-5	8	1	9
6-8	9	6	15
9-11	11	4	15
12-14	7	15	22
15-17	5	16	21
18-20		15	15
21-23		9	9
24-26		1	1
27-29		2	2
30-32		2	2
33-35			
36-38			
39-41			
42-44			
45-47			
48-50			
51-53			
54-56			
57-59			
60-62			

APPENDIX E

Distribution of Scores By Schools

FOURTH GRADE						
Interval	St. Felicitas (43)	St. Thomas More (33)	Komensky (34)	St. Ignatius (69)	Total (179)	
0-2						
3-5	8	1	4		13	
6-8	2	3	9	2	16	
9-11	2	3	6	4	15	
12-14	11	7	5	11	34	
15-17	7	3	3	17	30	
18-20	7	7	2	12	28	
21-23	3	3	3	14	23	
24-26	-	2	2	4	8	
27-29	1	2	-	3	6	
30-32	2	1	-	1	4	
33-35	-	1	-	1	2	
36-38						
39-41						
42-44						
45-47						
48-50						
51-53						
54-56						
57-59						
60-62						

APPENDIX F

Distribution of Scores By Schools

FIFTH GRADE							
Interval	St. Michael (30)	St. Alphonsus (34)	Smyser (47)	St. Thomas More (38)	St. Felicitas (47)	St. Ignatius (67)	Total (263)
0-2						1	1
3-5	1	3	2		3		9
6-8		2	1	1	2	2	8
9-11	2	1	3		3	1	10
12-14	5	4	8	3	3		23
15-17	9	7	7	6	8	10	48
18-20	5	5	3	6	8	12	39
21-23	3	1	12	6	9	11	42
24-26	3	5	6	5	5	11	35
27-29	2	3	3	4	1	7	20
30-32		1	2	2	1	7	13
33-35		1		2	2	4	9
36-38				3	1	1	5
39-41		1			1		2
42-44							
45-47							
48-50							
51-53							
54-56							
57-59							
60-62							

APPENDIX G

Distribution of Scores By Schools

SIXTH GRADE										
Interval	St. Felicitas (45)	St. Alphonsus (35)	St. Thomas More (35)	St. Michael (18)	St. Sebastian (36)	Smyser (44)	St. Ignatius (77)	St. Adrian (43)	St. Bride (40)	Total (373)
0-2										
3-5	1	1							2	4
6-8		2	1	2		1		2	1	9
9-11	1	3	1	2		1	2	1	2	13
12-14	2	1	1		2	6	3	1		16
15-17	4	6	3	5	6	6	6	10	5	51
18-20	8	2	5	5	4	10	11	4	7	56
21-23	8	3	8	2	9	7	8	9	5	59
24-26	7	5	5	1	7	3	17	5	2	52
27-29	5	3	3	1	5	6	12	6	6	47
30-32	4	5	1		1	3	7	2	6	29
33-35	4	3	2				4	1	3	17
36-38			2		1	1	3	1	1	9
39-41	1	1	2				2	1		7
42-44							1			1
45-47							1			1
48-50					1					1
51-53			1							1
54-56										
57-59										
60-62										

APPENDIX H

Distribution of Scores By Schools

SEVENTH GRADE

Interval	St. Ignatius (45)	St. Sebastian (52)	St. Felicitas (46)	Memorial Jr. High-Ind. (23)	Snyser (52)	St. Michael (29)	St. Thomas More (31)	St. Adrian (50)	St. Bride (48)	Total (376)
0-2										
3-5		1								1
6-8						2		2	1	5
9-11		1	1	1	1	1		1		6
12-14	1	2	3	1	4			2	2	15
15-17	1	2	3	1	13	2	1	6	1	30
18-20	6	11	7		9	4	1	4	4	46
21-23	5	7	5	2	5	5		11	8	48
24-26	6	4	6		10	3	7	5	7	48
27-29	4	7	8	1	6	3	7	10	12	58
30-32	8	5	2	1	2		6	5	6	35
33-35	8	4	8	7	2	5	3	3	3	43
36-38	2	7	1	2			1	1		14
39-41	3			2		3	3		3	14
42-44	1	2	1	2					1	7
45-47				2			1			3
48-50				1		1	1			3
51-53										
54-56										
57-59										
60-62										

APPENDIX I

Distribution of Scores By Schools

EIGHTH GRADE									
Interval	St. Ignatius (57)	Smyser (41)	St. Felicitas (43)	Memorial Jr. High-Ind. (24)	St. Michael (36)	St. Sebastian (37)	St. Bride (48)	St. Adrian (52)	Total (538)
0-2									0
3-5					2				2
6-8			1		2				3
9-11		1	1			1			3
12-14									0
15-17	1	2	2	1				1	7
18-20	2	3	5	1	2	2	1	3	19
21-23	1	3	4	1	2	3	4	2	20
24-26	2	12	4	3	4	5	9	7	46
27-29	4	5	5	4	4	9	7	10	48
30-32	10	5	5	4	4	8	7	7	50
33-35	8	6	5	3	3	5	6	7	43
36-38	10	2	2	4	5	1	6	4	34
39-41	8	2	2		3		3	1	19
42-44	4		2	1	1	1	3	1	13
45-47	2		3		1		2		8
48-50	1		2	2		1		6	12
51-53	2				2	1		2	7
54-56	1				1			1	3
57-59	1								1
60-62									0

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APPROVAL SHEET

The thesis submitted by Dorothy B. Auw has been read and approved by three members of the Department of Psychology.

The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated, and that the thesis is now given final approval with reference to content, form, and mechanical accuracy.

The thesis is therefore accepted in partial fulfillment of the requirements for the Degree of Master of Arts.

January 19, 1965
Date

[illegible]
Signature of Adviser